G. V. Houston

DEPARTMENT OF THE INTERIOR, CANADA
IRRIGATION BRANCH
E. F. DRAKE, Superintendent.

Canada

IRRIGATION SERIES
BULLETIN NO. 3.

REPORT

ON THE

CLIMATIC AND SOIL CONDITIONS

IN THE

CANADIAN PACIFIC RAILWAY COMPANY'S IRRIGATION PROJECT, WESTERN SECTION

(NEAR CALGARY, ALBERTA.)

OTTAWA
GOVERNMENT PRINTING BUREAU.
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Department of the Interior,
Irrigation Branch,
Ottawa, July 31, 1915.

W. W. Cory, Esq., C.M.G.,
Deputy Minister of the Interior.
Ottawa.

Sir,—I have the honour to submit herewith brief reports on the climatic and soil conditions in the Western Section of the Canadian Pacific Railway Company's irrigation project near Calgary, Alberta.

As you are aware, charges have frequently been made that the climatic and soil conditions within this tract are such as to preclude the successful practice of irrigated agriculture, although no conclusive evidence has been furnished in support of these charges. For the purpose of finally determining the truth or falsity of these allegations very careful studies of the soils and the climatic conditions have been made and the results are now available in the reports submitted herewith.

I recommend that these be printed for distribution among those who are more particularly interested in the settlement and development of this district.

I have the honour to be, sir,
Your obedient servant,
E. F. DRAKE,
Superintendent of Irrigation.

Department of the Interior,
Irrigation Branch,
Calgary, Alta., June 24, 1915.

E. F. Drake, Esq.,
Superintendent of Irrigation,
Department of the Interior.
Ottawa.

Sir,—I have the honour to submit herewith a report of the work done under my charge during the year 1914, on climatic conditions and the temperatures of the water in irrigation canals, with reference to the Western Section project and Lethbridge project, operated by the Canadian Pacific Railway.

During the past few years there has been some dissatisfaction amongst the holders of water rights in the C.P.R. Western Section project, and this has been expressed very largely by the quotation of unproven statements, that the climatic conditions in this district were not suited to irrigation, and also that the temperature of the water diverted for irrigation from the Bow river was so low as to seriously retard the growth of any crops to which it was applied.

In view of these statements having been so frequently made, it was considered desirable to investigate the matter, and now that the reports have been completed, while they are to some extent only preliminary, it is considered desirable that they should be published in order to place these questions before the interested public in a true light.

I have the honour to be, sir,
Your obedient sevrant,
F. H. PETERS,
Commissioner of Irrigation.

REPORT ON THE CLIMATIC CONDITIONS IN THE WESTERN SECTION OF THE CANADIAN PACIFIC RAILWAY COMPANY'S IRRIGATED LANDS IN THEIR RELATION TO IRRIGATION,

BY

G. N. Houston, Mem. Am. Soc. C.E.,
Chief Field Engineer.

July 16, 1915.

The purpose of this investigation was to determine whether or not the climatic conditions on the Western Section are such as to make the practice of irrigated agriculture practically impossible as is claimed by certain farmers on this tract.

This work was begun in 1913 at the same time as the work of reclassification of the land, and has continued to the present date, July 16, 1915.

A large amount of data bearing on the problem has been collected and studied, resulting in the following observations.

General.

There are many factors entering into the profitable growth of agricultural crops, and these must be kept in mind when considering the reason for individual crop failures, as the apparent cause of the trouble is frequently not the actual one. These factors affecting successful farming may be grouped under the following general heads: character of soil; kind of crops and the order in which they are grown; character of seed; the previous experience of the farmer and his ability to recognize and adapt himself to new conditions; economic conditions governed by supply and demand, and climatic conditions.

These conditions have always influenced crop production to a greater or less extent and always will.

Crop failure which a few years ago was said to be due to seeding in the wrong phase of the moon or some other cause equally mysterious, is now recognized as being the result of natural laws. The aim of agricultural research to-day is to control these elements which enter into the farmers' problem so that the chances of a crop failure may be reduced to a minimum.

For instance, in the matter of soils it has been determined that there are very few locations where the ground is so deficient in plant food as not to be able to support vegetation, other influences being favourable.

There are certain bacteria, however, which are absolutely essential to the growth of particular agricultural crops, such as alfalfa, field peas, etc., which are not always found in the soil, but these can now be supplied by inoculation with earth from a field on which the crop has been produced successfully. In arid or semi-arid districts the soil is sometimes so heavily impregnated with soluble salts as to limit the vegetation to a few alkali resisting plants. It has been demonstrated that this condition can be practically eliminated by proper drainage, or at least controlled by cultivation so as to keep these salts from accumulating in large amounts at the surface where they will destroy agricultural crops.

The principles underlying the proper rotation of crops so that the fertility of the soil may be maintained, and the selection of seed for the purpose of improving the strain, are well understood and aid the farmer greatly in getting the maximum returns from his land.

The Departments of Agriculture of the Dominion and of the province of Alberta, as well as the United States, publish a large amount of valuable information for the farmer which may be obtained free of cost. By intelligently applying the principles given in these publications to his own special case the farmer may reduce the effect of new conditions to a minimum.

Farmers' co-operative associations for marketing crops, purchasing supplies, securing temporary help during harvest, etc., are controlling more and more the economic conditions.

Climate.

There is still, however, one very uncertain factor affecting the practice of agriculture, over which the farmer has little or no control, viz., climate. A hail storm cannot be predicted, hence its ill effect must be offset by insurance. The effect of an unseasonable frost cannot be profitably averted except in the case of fruit culture, and not always then. As yet no successful method has been found to control rainfall, or even predict it far enough in advance to be of commercial value.

While little has been accomplished toward controlling the weather much has been done toward developing types of plants which are more immune to the weather conditions.

In this investigation the climatic conditions in the Western Section have been compared with places, having a similar climate, where irrigation has been practised successfully. The data used have been almost entirely collected by government officials, the only exception being the maximum and minimum temperatures at Strathmore during 1914 and the local rainfall for 1914 at various points in the Western Section which were taken by officials of the Canadian Pacific Railway Department of Natural Resources. The points chosen for comparison are:—

(1) The San Luis Valley, Colorado, where owing to the high altitude (7,500 feet) the climatic conditions are similar. This valley is about 100 miles long and 50 miles wide. Irrigation has been practised there for the past forty years.

Within recent times large projects have been built near Blanca and San Luis in this valley. Mixed farming is chiefly practised and the principal crops raised are wheat, oats, native hay, alfalfa, field peas, barley and potatoes.

(2) Meeker, Colorado (altitude 6,000 feet), is the centre of small irrigated farms with several large schemes projected in the vicinity.

(3) In Northern Montana the United States Reclamation Service is spending a large amount of money to furnish water to over 300,000 acres of land on the Blackfeet and Milk river projects where irrigation has been practised in a small way for many years. The crops produced on these projects are recorded as alfalfa, grain and vegetables; the soil is sandy loam and gumbo.

Crop Growing Season.

The period between the last killing frost in the spring, and the first in the fall limits the character of crops which can be grown in any section to those which will mature during this period. This interval is known as the crop growing season.

At many stations maintained by the United States Weather Bureau actual observations have been made of the length of this period. When none are available, however, it is customary to assume that a temperature of 32° F., results in a killing frost. As there are no official records regarding this matter for points under consideration in southern Alberta this method is followed, that is, the crop growing season is assumed to be the period between the latest date in the spring on which the temperature reached 32° F. and the earliest date in the fall on which it reached the same mark. While the crop growing season thus obtained would represent very conservatively the period during which potatoes and the more tender plants must appear above ground and grow to maturity it would not be the same period for grains as they will survive a temperature of several degrees below freezing point in the spring, making the growing season much longer for these crops.

The crop-growing season in the Western Section varies from 75 days to 131 days, or an average of 101 days. In the San Luis Valley, Colorado, it varies for the different locations as follows: the days are shown in detail because the records do not extend over a sufficient number of years to get a fair average.

TABLE No. 1—Crop Growing Season in the San Luis Valley and Meeker, Colorado.

San Luis Valley, Colorado.	1909.	1910.	1911.	1912.	1913.	1914.
	days	days	days	days	days	days
Blanca	96	99	112		92	93
San Luis	104	130	125	97	94	107
Saguache		138	90	82	120	109
Manassa	97	95	102	72		
Meeker, Colo.	103	67	57	76		

In northern Montana the average crop growing season is, for the Blackfeet project 104 days, and for the Milk river project 112 to 126 days.

On the Alberta Railway and Irrigation Company's tract near Lethbridge the crop growing season varies from 80 to 132 days, average, 108 days.

Maturing of Crops.

It is claimed that the irrigation of grain on the Western Section, especially wheat, results in prolonging the maturing so late that it carries it beyond the limit of the crop growing season.

Table (2) shows the date of ripening and the number of days necessary to mature, for various varieties of wheat, oats and barley, both irrigated and dry, compiled from the reports of the Government Experiment Station at Lethbridge for the years 1909 to 1914 inclusive.

The period necessary to mature dry wheat varied from 116 to 128 days, depending upon the variety and the year, the average being 123 days. The period for irrigated wheat varied from 113 to 139 days, the average being 126 days. That is, it requires on the average only three days longer to mature properly irrigated wheat.

In the case of oats the maturing period was: Dry, 102 to 123 days, average 112 days; irrigated, 113 to 130 days, average 119 days, or on the average 7 days longer to ripen the irrigated oats.

Dry Six-Row barley varied from 90 to 111 days, average 103 days, while the same irrigated ran from 98 to 114 days, average 107 days, or an average of 4 days longer to mature. Two-Row barley shows an average of 3 days longer to ripen when irrigated.

In general it may be said that the irrigation of grain tends to slightly prolong the period of maturing.

The average date of the first killing frost (assumed 32° F.) in the fall on the Western Section is about September 4. The earliest recorded date of this frost is August [illegible]. The average time necessary to mature irrigated wheat is 126 days. This indicates that wheat seeded before April 15 will probably mature before a killing frost in the fall. If care is used to select the early varieties this is made quite certain for the average year.

Oats and barley mature in a much shorter time and therefore should easily ripen within the crop growing period, especially if the early varieties are planted.

Table 2 has an additional interest when the yields per acre from irrigated and non-irrigated grain are compared. Wheat shows an average increase due to irrigation, of about 15 bushels per acre, or 56 per cent. Oats show an average increase of about 32 bushels to the acre or 50 per cent. Six-Row barley shows an increase of about 28 bushels per acre or 87 per cent, Two-Row barley shows an increase of about 25 bushels per acre or 70 per cent.

TABLE 2.

Maturing Period, and Yields per Acre, of Wheat, Oats, and Barley, at Lethbridge, Compiled from Official Reports of the Government Experiment Station

Year	Date of Ripening				No. of Days Maturing				Yield per Acre				Weight per Measured Bushel			
	N I		Irr.		N I		Irr.		N I		Irr.		N I		Irr.	
	From–To	Avg.	From–To	Avg.	From–To	Avg.	From–To	Avg.	From–To	Avg.	From–To	Avg.	From–To	Avg.	From–To	Avg.
	* No record N I grain in 1912. Destroyed by hail.															
	WHEAT								Varieties, 1909-1912 Percy, White Fife, Red Fife Marquis, Stanley; " 1913-1914 Red Fife, Marquis, Stanley							
1909.	Aug. 7–Aug. 17	Aug. 1[illegible]	Aug. 10–Aug. 17	Aug. 15	116–120	120	118–125	123	29–35.0	31.5	22.75–43.2	39.33	57.5–62.75	59.5	6[illegible].5–64.0	63.0
1910.	" 12 – " 14	" 13	" 17 – " 20	" 19	126–128	127	113–116	116	28.5–31.0	29.6	34.0–43.0	38.0	61.0–64.0	62.0	63.0–65.0	64.0
1911.	July 28 – " 1	July 28	" 8 – " 13	" 10	119–125	121	129–134	131	10.5–15.0	12.4	23.0–29.0	25.0	56.5–60.0	38.0	6[illegible].5–62.7	61.7
1912.	*		" 31	" 31			138–	138			41.75–50.75	5[illegible].8			No weights.	
1913.	Aug. 4–Aug. 9	Aug. 6	" 7–Aug. 20	" 11	123–128	125	[illegible]–13[illegible]	130	29.5–31.5	30.7	43.0–63.2	50.2	62.0–63.0	62.5	63.5–64.0	63.7
1914.	" 2 – " 6	" 4	" 2 – " [illegible]	" 4	131–125	123	119–123	121	28.0–32.0	25.3	44.0–52.0	47.0	59.0–61.2	60.0	59.7–63.7	61.3
Averages.		Aug. 8		Aug. 15		123		126		26.6		41.9		60.4		62.6
	OATS.								Varieties Improved American, Irish Victor, Abundance, Banner							
1909.	Aug. 1–Aug. 4	Aug. 2	Aug. 7–Aug. 10	Aug. 8	105–108	106	113–116	1[illegible]4	74.0–85.0	80.0	81.0–88.0	85.0	30.0–32.0	31.0	36.0–39.5	38.0
1910.	" 9 – " 11	" 10	" 16 – " 19	" 18	110–112	111	115–118	117	34.75–83.0	63.0	77.67–90.0	82.5	37.5–41.0	39.75	40.0–43.0	41.0
1911.	July 25 – " 1	July 28	" 11 – " 18	" 15	102–108	104	116–125	122	21.0–24.76	23.75	68.8–75.8	71.0	33.0–37.0	35.2	37.0–39.0	38.0
1912.	*		" 24 – " 25	" 24			129–130	129			79.4–90.0	84.25			No weights	
1913.	Aug. 17	Aug. 17	" 10 – " 14	" 11	128–	123	116–120	117	77.37–87.27	81.28	105.5–145.26	133.6	36.0–37.0	36.2	35.0–39.5	37.75
1914.	" 4–Aug. 5	" 5	" 4	" 4	116–117	117	1[illegible]5–	115	64.4–82.53	73.38	115.0–132.[illegible]	123.4	30.5–38.7	37.55	40.0–41.6	40.6
Averages.		Aug. 7		Aug. 13		112		119		64.[illegible]		96.6		35.94		39.19

Six-Rowed BARLEY

Varieties, 1909-1912 Claude, Mansfield, Mensury, Odessa.
" 1913-1914 Claude, Mansfield, Odessa.

1909	July 30–July 31	July 30	July 29–Aug. 5	Aug. 1	99–100	99	96–106	103	37 8	55 4	43 5	37 2	59 75	47 75	44 0	45 0	46 4	48 0	52·0	49 6
1910	Aug. 4–Aug. 9	Aug. 8	Aug. 13–" 16	" 15	90–95	93	98–101	100	31 8	48 75	40 75	53 75	63 75	59 4	49 5	54 0	51 6	54 0	57 0	56 0
1911	" 8–" 19	" 11	" 12–" 19	" 15	101–106	104	106–111	108	10·6	12·5	11 25	25 0	42 5	33 75	45·0	48 0	45·8	48 0	50 5	49 5
1912	*		" 16–" 23	" 20			107–114	110				51 25	81 25	64 75				No weights.		
1913	Aug. 3–Aug. 5	Aug. 4	" 5–" 8	" 7	107–109	108	109–112	111	27 4	34 3	30 1	61 7	81 6	74 5	50 0	53 0	51 17	50 5	54·0	52 7
1914	" 4–" 5	" 5	" 2–" 4	" 3	110–111	110	109–111	110	35 0	40·0	38 3	84 0	93 6	89 5	46 5	47 0	46 8	49 5	53 0	51 3
Averages		Aug 6		" 10		103		[illegible]			32 8			61 6			48 35			51 8

Two-Rowed BARLEY

Varieties, 1909-1912 : Swedish Chevalier, Standwell, Invincible, Clifford.
" 1913-1914 Swedish Chevalier, Invincible, Clifford

1909	July 30–July 31	July 31	Aug. 3–Aug. 8	Aug. 6	99–100	100	104–109	107	41 5	58 5	50·0	35 25	70 0	50 75	45 0	49 0	47 25	52 0	55 0	53 6
1910	Aug 12–Aug. 14	Aug. 13	" 17–" 19	" 13	99–100	99	102–104	103	31 25	43 75	37 5	64 33	68 75	66 6	52 5	58 6	53 1	57 0	57 0	57 0
1911	" 13–" 31	" 19	" 18–" 23	" 22	106–124	117	111–116	115	9 33	15 5	11 8	27 5	53 75	42 0	48 33	50 73	49 8	49 8	50 5	51 3
1912	*		" 18–" 23	" 22			108–114	113				41 25	70 0	59 33				No weights.		
1913	Aug. 8–Aug. 21	Aug. 10	" 7–" 20	" 15	112–125	120	109–124	118	30·0	42 6	37 9	52 8	77 4	65 3	52·0	53 0	52 7	51 0	55 5	53 8
1914	" 4–" 5	" 4	" 1–" 10	" 6	110–111	110	108–117	112	35·0	50·0	43 1	65 0	94 3	83 1	49 0	51 0	50·0	53 2	54 0	53 5
Averages		Aug 11		Aug. 16		108		111			36·00			61 36			50 57			53 90

Local Frosts.

It is further claimed that frosts occur every month of the year in this section.

An inspection of the records for 1914 shows that in general the temperature conditions are the same at Strathmore as at Gleichen but it also indicates that there are sudden local changes which are not common to both places. For instance, on June 22, 1914, the minimum temperature at Strathmore was 27°, that is 5 degrees of frost; the lowest temperature at Gleichen on the same date was 35°; at the government camp, thirteen miles south and eight miles west of Strathmore (Sec. 17, 22, 26) it was 31° F. It is evident that this frost was entirely local. Its effect on the crops in the vicinity was not serious. It will be noted that this temperature was below that usually considered fatal to wheat. On the government experiment plots at Strathmore the non-irrigated wheat was slightly frosted while the irrigated wheat close by was untouched. This is what would be expected, because the presence of irrigation water tends to keep the ground at a low uniform temperature.

At the government reclassification camp last year, 1914, careful records of temperature were kept. The first killing frost in the fall occurred while at Nightingale on September 1; in Strathmore it occurred on August 31. Heavy frosts were recorded at Nightingale on September 2, 5 and 6, and in Strathmore on 12, and yet on the 15th of September on the NE ¼ Sec. 29, tp. 25, rge. 23, at Tudor, about seven miles east of Nightingale, the potatoes had not been touched by the frost. There is no apparent explanation of this.

It is evident from the above that local frosts do occur at various points in the Western Section during the crop-growing period. It must be remembered in this connection, however, that the temperature may be several degrees below freezing and still not be a killing frost; for instance, the temperature of 27° at Strathmore mentioned above did not touch the potatoes or the irrigated wheat at the government plots.

Considering the fact that a temperature of 31° will kill potatoes and a temperature of 28° will usually set back wheat, it is evident that the temperature near the surface of the ground must have been 3 to 5 degrees higher than that shown by the thermometers at a height of about 4 feet above the ground.

Judging from the information gained from the farmers in this section, the local frosts do not occur in the same place every year and they are seldom fatal to the crops.

The official records at Gleichen run from 1903 to 1914 inclusive for all months of the crop-growing season except June, the records of which are not given for 1903 and 1913. Of the remaining ten years there were only two years in which the temperatures during June fell below 30° F. That is, there were only two years during these ten when there was a frost serious enough to affect the grain during June. June frosts, however, are not peculiar to the Western Section.

In the San Luis Valley, Colorado, we find that at Blanca, one year out of the five recorded, the temperature fell during June to 29° F., and that at least once during this month in every year the temperature fell below freezing.

At Saguache for two years out of the five given there were heavy frosts (25° F. and 28° F.). At San Luis, Colorado, for five years out of six there were frosts during June, two of which were very heavy (28° F. and 29° F.).

At Meeker, Colorado, there were frosts during this month in three out of the four years given, one of which was as low as 28° F.

Further, the records for Gleichen show that for eight years out of the twelve recorded there were two consecutive months during the cropping season in each year when there was no frost. Again, comparing this with the San Luis Valley we find that at Blanca, in all of the five years given, there were only two months in each cropping season free from frost. It is evident that irrigation is being successfully practised where the local frost conditions are as severe as in the Western Section.

Mean Temperatures.

Comparing the mean temperatures during the crop-growing season (May to August, inclusive) the records show that Medicine Hat, Alberta and Chinook and Glasgow on the Milk River project, Montana, have about the same temperature conditions and average about [illegible] degrees higher than Gleichen, Alberta. Lethbridge averages about 1 degree higher, Saguache, Colorado, 3 degrees higher, Cut Bank on the Blackfeet project, Montana, 2 degrees higher, San Luis, Colorado, 1 degree higher than Gleichen.

Rainfall.

It is also claimed that irrigation is unnecessary here as the rainfall is sufficient if properly conserved.

Irrigation is necessary wherever the available rainfall is insufficient to produce a profitable crop.

Irrigation is desirable wherever the available precipitation is insufficient to produce the maximum profitable yield per acre of the particular crops grown.

It will be noted that the governing factor is the available rainfall. Water is the most essential element in the growth of vegetation. "Dry Farming" is a misnomer, as no crop will grow without water. The essential difference between dry farming and irrigated farming is the quantity of water used. Dry farming is the practice of the most efficient methods for the conservation of water and rendering it available for the crops. These same principles, however, should apply equally well to irrigated farming. In fact there are many irrigation projects in the United States today which, on account of the limited water supply, must depend for their success upon the intelligent application of dry farming principles to their crop production.

The necessity or desirability of irrigation cannot always be inferred from the annual precipitation. Irrigation has been practised on a large scale for many years in Italy where the annual rainfall is 40 inches, and in India where it is 100 to 300 inches, with 5 inches to 10 inches precipitation during the principal cropping season. The annual rainfall in Gleichen averages 14 inches, of which about 10 inches fall during the cropping season. That of Lethbridge averages 16 inches, of which about 8 inches fall during the cropping season. Chinook, Montana, has [illegible] inches with 7.8 inches during the season. Glasgow, Montana, has 13.3 inches with 7.9 inches during the season. Cut Bank, Montana, has 11.5 inches with 7.5 inches during the season. The large irrigated valleys of Eastern Colorado, along the Platte and Arkansas rivers, average 15 inches yearly with 7 to 10 inches during the crop-growing period. San Luis, Colorado, averages 11.4 inches yearly and 5.6 inches during cropping season.

The rainfall during the cropping season is therefore the governing factor as to the necessity or desirability of irrigation. This is particularly so in the Western Section as the precipitation between October 1 and April 1 usually falls on frozen ground and, if in the form of snow, melts and evaporates quickly, very little, if any, getting into the ground. April has very little rainfall, averaging a little more than half an inch. It is assumed that the rainfall during the months of May, June, July and August have a direct effect on the crops, as these are the months during which most of the growth takes place.

Comparing points in southern Alberta with points on the Blackfeet and Milk River projects we find that Calgary, Gleichen, Lethbridge and Chinook have nearly the same average rainfall during May. The mean for Glasgow, however, is .75 inches more than for Gleichen. During June the average rainfall in Lethbridge, Chinook and Glasgow are substantially the same, but Gleichen is slightly higher (about 0.3 of an inch). In July Gleichen apparently has about 0.6 inches more rainfall on the average than Lethbridge and Chinook. This, however, is due entirely to the exceptionally heavy rainfall during this month in 1909. If this year be left out in the calculation, the means for the three places would be practically the same.

Considering the whole period, May to August inclusive, we find that Gleichen averages about one inch more rainfall than Lethbridge and Glasgow and about two inches more than Chinook. If, however, we leave out the exceptionally heavy rain, 8 inches of July, 1909, the rainfall during the crop growing season in Gleichen will average about the same as in Lethbridge and Glasgow, which more nearly represents the actual conditions.

The rainfall records for Gleichen and Lethbridge extend back for a period of twelve years (1903) only, whereas those of Calgary have been kept for nearly thirty years.

The Calgary records show that for eleven years (1885 to 1896) the average rainfall during May to August inclusive was [illegible]·4 inches or about 3·9 inches less than the average for the last 12 years (1903 to 1914).

It is fair to assume that this condition affected the Western Section to some extent, although the records show that it did not extend as far south and east as Medicine Hat. It is safe to say in regard to weather conditions that whatever has occurred will in all probability occur again.

The condition during this dry period on the Western Section was very like the condition in 1910 and 1914 during which years dry farming was of very little use without the assistance of irrigation.

The total rainfall during the cropping season alone, however, is not sufficient to indicate the necessity or desirability of irrigation. The efficiency of this precipitation in producing crops depends upon its distribution during the season and the rate of evaporation, as affected by temperature, relative humidity and wind velocity.

Considering northern Montana and southern Alberta it has been assumed that the effect of the rate of evaporation upon the moisture available for crop production would be practically the same. This leaves the distribution of the rainfall, or conversely the occurrence of drought periods during the cropping season, as the principal factor in crop production.

The daily distribution of the rainfall from May 1 to August 15, was studied for the years 1903 to 1915 inclusive for points in southern Alberta and northern Montana. The investigation was limited to the first of May because the records of April were not complete for all the places which were considered, and for the further reason that the rainfall during April at Gleichen averages only about 0·6 inch. It was limited at the other end to August 15 because drought conditions after this date would have no effect upon the crops.

Table 8 shows the results of these studies. The first column under each location gives the length of each drought period, the second column the total rainfall during the period, the third, the number of days on which rain fell, the fourth the maximum amount which fell on any one day.

It is not to be inferred from these data that the crops could not survive these dry periods. The object of the study is simply to show that the distribution of the rainfall in the Western Section is similar to that in other locations where irrigation has been successfully practised.

In considering these periods of light rainfall, it should be remembered that a precipitation of less than one half inch falling upon a dry soil, or upon a mulch, such as should be maintained on the surface of a proper summer fallow, is of no value for storing water, although a small percentage may become available for the immediate use of a crop and thus assist in carrying it over the dry spell. Further, a rainfall of less than one-half inch not preceded or followed within a day or two by further rain is usually a local shower.

At the bottom of each column will be found the averages for the whole number of years. The average length of these periods in the Western Section assuming the conditions at Gleichen to be representative is 25 days. In Lethbridge and Medicine Hat they average two days longer. In Chinook and Cutbank drought conditions are practically the same as Gleichen. The incomplete records of Glasgow indicate somewhat longer periods of drought.

The averages of the second column show that while Lethbridge and Medicine Hat have slightly longer periods of drought they also have a third more rainfall during the drought, distributed over 4.7 days as compared with 2.1 days at Gleichen.

It is a well recognized fact that on any arid or semi-arid tract of the size of the Western Section climatic conditions vary owing to local showers. It has therefore been assumed throughout this discussion that the conditions shown by the records at Gleichen, Lethbridge, Chinook and the other stations cited are representative for the sections in which they are located.

Conclusions.

1st. The climatic conditions in the Western Section are similar to those in several other places where irrigation has been successfully practised for many years and therefore there is no reason, so far as climate is concerned, why it should not be successful there.

2nd. From the above discussion considered in connection with the additional yield of grain due to irrigation as shown in Table 2 and the fact that 13,000 acres of alfalfa were successfully irrigated during 1914 in the vicinity of Lethbridge, as well as the results of irrigation as practised on the Cammeart farm near Strathmore, under government direction last year, it is evident that irrigation is very desirable on the Western Section.

3rd. In the event of another dry period such as occurred from 1885 to 1896 on the Western Section, it is evident that irrigation would be an absolute necessity.

TABLE 3.

SUMMARY of the studies of Drought conditions in Southern Alberta and Northern Montana.

—	Calgary: Length of Period. Days.	Calgary: Total Precipitation in Period.	Calgary: Number days on which rain fell.	Calgary: Maximum for one day.	Gleichen: Length of Period. Days.	Gleichen: Total Precipitation in Period.	Gleichen: Number days on which rain fell.	Gleichen: Maximum for one day.	Brooks: Length of Period. Days.	Brooks: Total Precipitation in Period.	Brooks: Number days on which rain fell.	Brooks: Maximum for one day.
1913	35	·46	2	·45	27	00	0	00	35	·63	12	·24
	30	·34	8	·07	23	·02	1	·02				
					17	38	2	25				
1912	17	·24	5	10	18	17	3	10	17	17	2	10
	21	14	6	·06	26	24	2	26	18	·08	2	·05
					17	20	2	15	22	38	2	12
					20	·26	3	10				
1911	..			.	24	00	0	00	15	·36	3	12
					17	00	0	00	26	13	4	10
									23	·44	7	13
1910	17	·03	1	·03	81	85	2	·30	82	·82	1	22
	42	·56	8	14	64	00	0	·00	19	·29	8	73
1909	18	·34	5	12	37	56	4	44				
1908	18	34	6	11	36	55	4	·25				
1907	18	80	4	·16	19	14	1	14				
	21	38	5	·20	21	32	2	18				

—	Medicine Hat: Length of Period. Days.	Medicine Hat: Total Precipitation in Period.	Medicine Hat: Number days on which rain fell.	Medicine Hat: Maximum for one day.	Lethbridge: Length of Period. Days.	Lethbridge: Total Precipitation in Period.	Lethbridge: Number days on which rain fell.	Lethbridge: Maximum for one day.
1913	27	17	4	10	31	63	6	29
	31	23	2	22	19	27	4	·20
1912	26	·39	7	10	26	·34	6	16
	17	17	3	13	23	·07	2	·06
	19	·30	3	16				
	21	·33	6	17				
1911	20	30	8	10	18	13	3	·06
					24	48	8	14
1910	63	·86	11	16	41	45	8	16
	31	·58	5	22	39	·06	2	·06
1909	25	49	2	39	48	·30	11	·22
					15	15	4	·05
1908	25	·24	4	07	49	·54	5	19
	32	·49	7	17				
	24	·40	5	14				
1907	19	·05	1	08	21	43	7	·08
	17	·20	2	15				
	20	·23	5	10				
	24	·30	8	14				

—	Chinook, Mont.: Length of Period. Days.	Chinook, Mont.: Total Precipitation in Period.	Chinook, Mont.: Number days on which rain fell.	Chinook, Mont.: Maximum for one day.	Cutbank, Mont.: Length of Period. Days.	Cutbank, Mont.: Total Precipitation in Period.	Cutbank, Mont.: Number days on which rain fell.	Cutbank, Mont.: Maximum for one day.	Glasgow, Mont.: Length of Period. Days.	Glasgow, Mont.: Total Precipitation in Period.	Glasgow, Mont.: Number days on which rain fell.	Glasgow, Mont.: Maximum for one day.
1913	25	41	2	·23	21	27	2	20	26	47	3	·29
	17	16	1	18	20	·00	0	·00	33	60	7	·22
1912	20	40	2	38	20	·00	0	·00				
	39	·48	3	23	34	·50	5	19				
	17	·28	2	19								
1911	20	12	1	12	21	40	3	·22	32	43	3	19
					40	·60	5	10	19	11	1	11
1910	31	·62	7	12	27	45	3	·23				
	37	·08	3	03	38	·00	0	·00				
1909	14	·03	1	03	19	00	0	·00				
	27	·50	2	33								
1908	10	34	3	19								
	43	19	2	11								
	18	15	3	08								
1907	19	·07	1	·07					22	23	6	00
	28	20	4	10					31	19	3	13

1906	17	32	7	10	19	·90	3	13					13	·00	0	00	31	61	4	·21	48	·00	1	·09					34	30	4	19
	19	19	3	14	28	·39	1	39					49	40	6	10	16	13	1	13												
1905	19	·28	3	12	20	·23	8	10					17	34	4	32	21	36	6	25	18	22	1	22								
	18	·29	3	·20	18	·32	8	22					20	14	2	·08	25	24	5	·06	14	00	0	·00								
	25	44	5	·20									32	64	7	16																
	18	·03	2	·06																												
1904	21	·43	4	18	31	·26	2	20					19	38	4	14	46	42	4	19	18	10	1	10					30	·52	4	30
	19	36	4	25	45	·39	4	13					43	84	7	20					21	08	1	·08					64	·54	4	20
	20	28	3	16									22	46	2	36																
1903	17	31	3	15	14	·25	1	25					65	1 00	12	35	16	09	2	03	26	47	3	·30					16	·02	2	01
					31	·51	5	24									25	28	6	07	18	15	1	15					23	·47	4	19
					17	12	3	08									21	20	3	19												
Mean.	21	301	4·3	15	25	260	2 1	164	2 86	·360	5 1	144	27 ·3	·880	4·69	156	27 4	·334	4 8	144	24 4	222	2·0	149	26 1	246	2·0	111	30	·361	3·73	166

84068—2

July 16, 1915

Approved,

G N. HOUSTON,
Chief Field Engineer

REPORT ON THE TEMPERATURE OF THE WATER IN THE IRRIGATION CANALS AND LATERALS ON THE WESTERN SECTION OF THE CANADIAN PACIFIC RAILWAY COMPANY'S IRRIGATED LANDS, 1914.

BY

G. N. Houston, Mem. Am. Soc. C.E.,
Chief Field Engineer

July 16, 1915.

The data on which this report is based consist of the following

(1) Temperature of water in canals and laterals at various points in the Western Section covering a period from July 12 to September 30, 1914. Collected by the Canadian Pacific Railway Company.

(2) Similar data taken by Mr. R. J. McGuinness, government hydrometric engineer, covering a period from June 10 to August 12, 1914.

(3) Data similar to the above taken by myself covering a period from June 12 to August 31, 1914.

(4) Temperatures of water in canals and laterals taken at various points of the Alberta Railway and Irrigation Company's system by Mr. McGuinness during the Months of July and September, 1914.

(5) Temperatures of the Bow River water near the headgates of the Canadian Pacific Railway Canal, Western Section, taken by Mr. R. J. Srigley, covering a period from July 15 to September 30, 1914.

(6) Temperatures of the St. Mary river at the headgates of the Alberta Railway and Irrigation Canal near Kimball, Alberta, taken by Mr. J. M. Dunn, covering a period from June 9 to September 26, 1914.

The purpose of this investigation was to determine whether or not the temperature of the irrigation water was so low as to seriously retard the growth of crops, as has been claimed by some of the farmers of the Western Section.

A careful study of the data at hand shows that there is a daily fluctuation in the temperature of the ditch water. This depends upon the quantity of water flowing in the canal. The less the quantity of water the greater is this daily change. It is also evident from Table 1 that there is a periodical change, for instance the average of all temperatures in canals for June was 62 degrees, in July 69 degrees, and in August 63 degrees, showing about a 7 degrees rise in the average temperature corresponding to the general rise in the mean temperature of the air.

The temperature of the water is also affected by the distance the observer is from the headgates on the Bow river. In general the data show that the farther the water runs from the headgate the warmer it becomes. The temperature of the water entering the headgates on July 10 was about 56 degrees, on the 11th at Strathmore it was 70 degrees, a gain of 14 degrees. From June 23 to 26 the water on the Bow river at the headgates was about 48 degrees, on the 26th in a lateral about thirty-one miles from the headgates it was 72 degrees, a gain of about 24 degrees. On the 24th in another lateral, about forty-one miles from the headgates the temperature was 64 degrees, a gain of 16 degrees. On June 30 the temperature of the Bow river was 51

degrees. Allowing three days for this water to reach the Gleichen district we find on July 2, temperatures of 77 degrees and 80 degrees in the distributaries of this district about 92 miles from the headgates.

The temperature of water in the canals and laterals which are so situated as to catch the run-off of the adjoining land is affected by the precipitation. This is most clearly shown in the small laterals where the proportion of incoming water is a much larger percentage of the amount running than in the canals. This incoming water lowers the temperature of the water in the laterals, from which the inference is that the temperature of the rain was lower than that of irrigation water.

Three observations of the temperature of rain water were taken by the C.P.R. officials which range from 46 degrees to 52 degrees. This apparently confirms the above conclusion.

Table 1 is a summary of 143 observations of temperature taken during 1914 in the Western Section. Table 2 is a summary of 17 observations taken during July, 1914, on the Alberta Railway and Irrigation Company's system.

It will be noted that the ditch water in the canals and laterals of the Western Section averages 4 degrees to 5 degrees warmer during July than on the Alberta Railway and Irrigation tract where irrigation is being practised successfully. Irrigation has been carried on in the vicinity of Logan, Utah, for many years. Bulletin No. 115 of the Agricultural Experiment Station of that state gives the following as the temperature of the water used. In June it varies from 48 degrees to 60 degrees, average 54 degrees or 9 degrees lower than the average for the Western Section. In July it varies from 45 degrees to 62 degrees, average 54 degrees, or 16 degrees lower. In August it varies from 49 degrees to 63 degrees, average 56 degrees, or 8 degrees lower.

Further the temperature of the water which was applied during July to the irrigation of an orchard in California, is recorded at 65 degrees, that is 5 degrees lower than the average temperature in the laterals of the Western Section during the same month. (See Bulletin 203, United States Department of Agriculture. Page 49)

The temperature of irrigation water used in experiment in Oregon is recorded as 65 degrees, that is 5 degrees lower than the average in the laterals of the Western Section for July and 1 degree lower than the average for the season. (See Bulletin No. 122, Oregon Agricultural Station, Page 30)

Conclusions.

(1) The water applied to crops on the Western Section is of a higher temperature than that used in many places where irrigation is carried on successfully.

(2) The water applied to crops on the Western Section is generally of a higher temperature than the rain water.

(3) The application of irrigation water to the crops in the Western Section will not result in seriously retarding their growth.

TABLE 1.—Summary of 143 Observations of the Temperature of the Water in Canals and Laterals on the Western Section during the Months of June, July and August 1914

Location	June			July			August		
	Max	Min.	Avg.	Max	Min.	Avg	Max.	Min.	Avg.
Secondary A	66	57	63	71	62	67	64	57	61
Laterals under Sec. A	71	55	66						
Secondary B, south	67	57	64	75	74	74			
" B, north	70	53	62	69	65	66			
" C, west	58	54	55				63	59	61
" C, east	74	55	62	71	62	63	70	61	65
" A, south	72	50	58	69	63	66	65	59	62
Distributary B, Gleichen	64	56	60	81	76	74	71	61	66
All canals	72	50	63	81	62	69	71	57	63
All laterals	8	52	63	72	66	70	67	60	64

TABLE 2.—Summary of 17 Observations of the Temperature of the Water in Canals and Laterals of the A. R. & I. System during July of 1914

Canals				67	58	64			
Laterals				69	64	66			

Approved.

G. N. HOUSTON,
Chief Field Engineer.

July 16, 1915.

DEPARTMENT OF THE INTERIOR, CANADA,
IRRIGATION BRANCH.

OTTAWA, March 2, 1915.

Dr. F. T. SHUTT,
Dominion Chemist,
Central Experimental Farm,
Ottawa.

Dear Dr. SHUTT,—I beg to acknowledge the receipt of your letter of the 27th ultimo, in which you summarize the conclusions which you have reached from the analyses of soils and a personal examination of the land in the Western Section of the Canadian Pacific Railway Company's irrigation tract last year.

I am glad to know that in your opinion the land in this tract is not generally impregnated with alkali, that the soil is rich and suitable for agricultural purposes, and that if due attention is paid to drainage and to the prevention of excessive seepage from canals, good results may be anticipated from irrigated agriculture, provided the the water is intelligently applied, with due regard to soil and climatic conditions.

I quite agree with you as to the desirability of an educational campaign. Very great attention is being paid all over Canada just at present to better farming methods but little, if any, attention has heretofore been given to the teaching of methods adapted to irrigated agriculture. We have attempted some work in this direction during the past two years and anticipate extending this branch of our work during the present year. The results so far have been distinctly good and we hope that our work in the future will prove even more beneficial.

Yours very truly,

E. F. DRAKE,
Superintendent of Irrigation.

REPORT ON SOILS IN THE WESTERN SECTION OF THE CANADIAN PACIFIC RAILWAY COMPANY'S IRRIGATION PROJECT.

BY

Frank T. Shutt, M.A., D.Sc., F.I.C.

Dominion Chemist.

OTTAWA, February 27, 1915.

E. F. DRAKE, Esq.,
Superintendent of Irrigation,
Department of the Interior,
Ottawa.

Western Section of C.P.R. Irrigation Tract.

DEAR MR. DRAKE,—In the early part of 1914, having some months previously undertaken for your department the analysis of a number of soil samples from this district, I was impressed with the desirability of visiting the area with a view, more particularly, of learning how far actual observation in the field might confirm the reports already made by us regarding the character (saline content, etc.) of the soils examined.

Further, having in 1906 made a preliminary agricultural survey of a portion of this area and reported that I had found the soils, over the area traversed, as generally fertile and bearing signs of a high degree of productiveness (see report of the Dominion Chemist, 1906), I thought it would be helpful in any report that I might be called upon to make respecting the suitability of the district as a whole for agriculture under irrigation, to observe such changes, if any, as had resulted from the introduction of irrigation and more particularly as to rise of alkali from the legitimate use of irrigation water and from seepage from canals and ditches.

To this end, therefore, I arranged, while on my tour of inspection of our Western Experimental Farms and Stations last year, to again visit this district, and during the first two weeks of August, in company with yourself and several of the engineers in charge of the work of reclassification, I inspected much of the area previously reported on, paying particular attention to the examination of those localities in which water had been used one or more seasons and those from which soil samples had been collected and analysed.

The tour included an inspection of many large areas in the districts of Gleichen, Bassano, Strathmore, Langdon and Brooks and points at the Winona and Crowfoot headquarters. Full and detailed notes were made throughout, but it will be unnecessary to transcribe them for our present purpose, which is to give the outstanding conditions as generally observed and to state more particularly the impressions gained from this personal study in the field as to the influence of irrigation on the soils and crops in the districts visited. The observations and deductions may be summarized as follows:—

1. The natural occurrences of alkali in the districts traversed are not frequent, nor with a few notable exceptions do they cover large areas, so that speaking broadly these districts would not be considered as seriously affected, nor would they be debarred, from this cause from general occupation.

In all arid and semi-arid countries alkali areas naturally occur—sloughs, low flats, etc.—and the districts under consideration are, in this regard, no exception. Many

of these areas are, no doubt, from the economic standpoint irreclaimable, but my impression is that these are not of such magnitude as to preclude the possibility of successful settlement.

2. I have no hesitation in saying that the land generally is not impregnated with "alkali," that is, the soluble saline content of the soil is not generally such as to cause injury through "rise of alkali" when put under irrigation. This deduction is made after a careful consideration of the analytical data from a number of soil samples and was confirmed by my observations in the field last summer.

3. This second trip has confirmed the opinion expressed in my report of 1906 regarding the general fertility of the soil. As a whole, the area is overlaid by a surface soil with a fair to abundant proportion of humus and rich in plant food. (From the standpoint of fertility the soils as a rule bear the signs of more than average possibility, and with adequate moisture and favourable climatic conditions, should prove very productive.

4. Success in agriculture under irrigation depends largely on the character of the soil and subsoil. The subsoil especially should be "open" to allow ready percolation of the irrigation water. A heavy plastic clay or gumbo is especially undesirable as leading towards "water logging," sourness and rise of alkali. Such soils must be effectively underdrained and care exercised that excess of irrigation water is not employed. Heavy clay subsoils underlie portions of these districts and where these exist it will be imperative to observe the precautions here referred to or very serious difficulties will follow the application of water.

5. The alkali of these districts is almost entirely that known as "white alkali," a form much less injurious than "black alkali." Of the latter the occurrences are not numerous.

6. The water supplied by the system for irrigation purposes is entirely satisfactory from the standpoint of its mineral content, which is exceptionally low.

7. With respect to the effect of irrigation water on "rise of alkali" I remarked several instances of very serious and extensive injury undoubtedly due to excessive seepage from canals. It will be imperative in these and similar cases to immediately put in cut-off drains. Without this precaution it may be expected that these highly impregnated areas will increase in size and much valuable land ruined.

Where irrigation has been practised judiciously and with care, rise of alkali from the application of water was rare. Many farmers will be obliged to put in underdrains, and especially those on lands with a heavy impervious subsoil, to avoid the occurrence of alkali on their low-lying fields.

8. Many fine fields of luxuriant crops were observed as a result of irrigation, and these for the most part presented a great contrast to the poor and meagre growth on adjoining on lands under "dry farming" conditions. Indeed in many instances the dry land crops were a complete failure giving little or nothing to harvest.

Irrigated alfalfa was especially good, having in some instances yielded, at the time of our visit, two cuttings. Grasses and other forage crops also had given excellent crops under irrigation, in marked contrast to those without water. The cereals—wheat and oats—grown under irrigation were in some cases quite green and the fear was expressed that these might not ripen before there was danger from frost. Later in the season I was informed on good authority that these crops ripened and were satisfactorily harvested. Nevertheless, for these crops it may be found that irrigation the previous autumn will furnish sufficient water and prove the safer practice.

9. Many of the farmers on these lands have had no previous experience in irrigation and I was much impressed with the desirability of an active educational campaign in all matters pertaining to the art of growing crops with water. The larger number of the difficulties met with and the mistakes made were due, in my opinion, to ignorance. Farming under irrigation is a special branch of agriculture and as such must be

learnt It consists not only of a knowledge of the use and right application of water but also of drainage and of crops adapted to the soils and climatic conditions prevailing. I feel assured that the success of these irrigated districts will depend largely on the careful instruction of those on the land in these and related matters.

In conclusion it will be satisfactory to you to learn that in the case of the soils already reported on the results of our analyses were confirmed by the examination in the field emphasizing the value of the chemical and physical examination of the soils in this work of reclassification

Yours faithfully,

FRANK T SHUTT,

Dominion Chemist.

REPORT OF ANALYSIS OF WATER FROM THE IRRIGATION CANAL OF THE CANADIAN PACIFIC RAILWAY COMPANY.

BY

Frank T. Shutt, M.A., D.Sc., F.I.C.

Dominion Chemist.

OTTAWA, June 21, 1915.

WATER FROM IRRIGATION LATERAL IN THE NE. $\frac{1}{4}$ OF SECTION 12, TOWNSHIP 25, RANGE 27, WEST 4TH MERIDIAN, INVERLAKE DISTRICT, ALBERTA, FORWARDED OCTOBER, 1914.

ANALYSIS AND REPORT.

	P.P.M.	P.P.M.
Total solids at 105°	226.0	
Loss on ignition	75.0	
Solids after ignition	150.0	
Lime (CaO)		32.4
Magnesia (MgO)		26.8
Soda (Na_2O)		117.0
Sulphates (SO_3)		48.7
Chlorides (Cl)		0.0
Carbonates (CO_2)		39.6
		264.5

The mineral content of this water is equivalent to, approximately, 16 grains per gallon. The safe limit of salinity for irrigation is, by some authorities, put at 40 grains per gallon, but many waters employed for this purpose in the Western States contain 70 grains and even more, per gallon. It is practically impossible to state definitely what might be considered a limit or content beyond which a water becomes unfit and unsafe, as the nature of the salts making up that content, especially if that amount be high, must be taken into account. Further, the character of the soil and of the drainage, the amount of water to be used, etc., all complicate the question and would very materially influence an opinion on the suitability of an irrigation water with a high saline content.

In this case, however, no such consideration is necessary. The saline content is exceedingly low and though it contains a certain proportion of sulphate of soda it is markedly free from chlorides and magnesium compounds. It would seem, from our knowledge of irrigation waters, in general, that this water is exceptionally suitable for irrigation purposes and we are of the opinion that no fear need be entertained of harm resulting from its use; that is, in consequence of any injurious alkali which it might be thought to contain.

FRANK T. SHUTT,

Dominion Chemist.

REPORT OF A… …TION CANAL
OF TH… …ANY.

…e 21, 1915.

WATER FROM … SECTION 12,
TOWNSH… INVERLAKE
DISTRICT, …

	P.P.M.
Total solids …	
Loss on ignit…	
Solids after …	
Lime (C…	32.4
Magnesi…	26.3
Soda (N…	117.8
Sulphate…	42.7
Chloride…	0.0
Carbona…	39.6
	284.5

The mineral c… … 16 grains per gallon. The safe l… …ties, put at 40 grains per gallon, … Western States contain 70 grains … …ssible to state definitely what mig… … water becomes unfit and unsafe, a… …pecially if that amount be high, must be taken into account. Further, the character of the soil and of the drainage, the amount of water to be used, etc., all complicate the question and would very materially influence an opinion on the suitability of an irrigation water with a high saline content.

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FRANK T. SHUTT,
Dominion Chemist.